

IMPROVED SOLUTION OF THE LIDAR EQUATION
UTILIZING PARTICLE COUNTER MEASUREMENTS

H. Jäger and M. Littfass, Fraunhofer-Institute for
Atmospheric Environmental Research, D-8100 Garmisch
-Partenkirchen, FRG

D.J. Hofmann and J.M. Rosen, Department of Physics
and Astronomy, University of Wyoming, Laramie,
Wyoming 82071, USA

The extraction of particle backscattering from incoherent lidar measurements poses some problems. In the case of measurements of the stratospheric aerosol layer the solution of the lidar equation is based on two assumptions which are necessary to normalize the measured signal and to correct it with the two-way transmission of the laser pulse. Normalization and transmission are tackled by adding the information contained in aerosol particle counter measurements of the University of Wyoming to the ruby lidar measurements at Garmisch-Partenkirchen.

The widely accepted lidar normalization is the matching method which assumes a range existing in the stratosphere with negligible particle backscattering. The signals from such a range, usually from above 25 km, are adjusted to match the expected molecular return which is calculated from radiosonde density (or standard atmosphere) data.

The two-way transmission becomes an important correction when rather dense volcanic eruption clouds are observed. The correction is calculated from the extinction the laser pulse experiences on its way to and from the scattering volume under observation. The extinction in turn is calculated from particle backscattering measured by lidar thus causing an iterative calculation loop. The conversion factor involved, the backscatter-to-extinction ratio, is the crucial point in this procedure. For background or aged volcanic aerosol a value of about 0.015 1/sr is accepted (e.g. Russell and Hake, 1977), whereas much higher values are expected from fresh volcanic aerosols. Some values have been reported for the El Chichon period which are as high as 0.029 1/sr (Swissler et al., 1984).

Both quantities, normalization and transmission correction, can be calculated if the particle size distribution and the index of refraction are known. The balloon-borne particle counter soundings of the stratosphere by the University of Wyoming provide such data which allow the calculation of

- i time resolved particle backscattering from the height level of matching (which then adds to the molecular backscattering at this level)
- ii time and height resolved backscatter-to-extinction ratios

The cumulative particle concentrations of the six counter channels are differentiated with a height resolution of 1 km to fit a bimodal lognormal distribution. This model allows the description of the aerosol by 6 parameters (two modal radii, two modal widths and the total number concentrations in each distribution), thus providing for the proper treatment of the increased number of large particles after volcanic eruptions (Hofmann et al., 1983).

Calculated backscattering from height levels above 25 km for the El Chichon period will be compared with lidar measurements and necessary corrections will be discussed. The calculated backscatter-to-extinction ratios will be compared to those, which have been derived from a comparison of published extinction values (Rosen and Hofmann, 1986) to measured lidar backscattering at Garmisch (Jäger et al., 1984). These ratios have been used to calculate the Garmisch lidar returns. For the period 4 to 12 months after the El Chichon eruption a backscatter-to-extinction ratio of 0.026 1/sr has been applied with smaller values before and after that time.

References

Russell, P.B. and R.D. Hake, J. Atmos. Sci, 34, 163, 1977.

Swissler, T.J., D.J. Hofmann and J.M. Rosen, 12th Int. Laser Radar Conference, Aix en Provence, 1984.

Hofmann, D.J., J.M. Rosen, R. Reiter and H. Jäger, J. Geophys. Res., 88, 3777, 1983.

Rosen, J.M. and D.J. Hofmann, to be published in Appl. Opt., 1986.

Jäger, H., R. Reiter, W. Carnuth and W. Funk, Geof. Int. 23-2, 243, 1984.